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Adam Hulme, Neville A. Stanton, Guy H. Walker, Patrick Waterson & Paul M. Salmon. *Complexity theory in accident causation: using AcciMap to identify the systems thinking tenets in 11 catastrophes*. Pages: 821-838.

The quest to explain and understand the cause of accidents is both ever-present and ongoing amongst the safety science community. In an attempt to advance the theory and science of accident causation, researchers have recently formalised a set of '15 systems thinking tenets' that cover the conditions and characteristics of work systems that are believed to contribute to the cause of accidents. The purpose of this study was to attempt to identify the systems thinking tenets across a range of different systems and accidents using the Accident Mapping (AcciMap) method. The findings suggest that the tenets can be attributed to play a role in accident causation, however as a result of this process, the capability of AcciMap has been brought into question. Implications and directions for future research are described. **Practitioner Summary:** This study is an extension of previous work that suggested there was a need to test for the 'systems thinking tenets of accident causation' in a multi-incident dataset. We used AcciMap to evaluate whether it has the capability to support ongoing accident analysis activities in ergonomics research.

- **Keywords:** Accident causation, accident theory, accident analysis, AcciMap, systems thinking tenets

Omar Faruqe Hamim, Mithun Debnath, Shahnewaz Hasanat-E-Rabbi, Md. Shamsul Hoque, Rich C. McIlroy, Katherine L. Plant & Neville A. Stanton. *Resolving the differences between system development and system operation using STAMP: a road safety case study in a low-income setting*. Pages: 839-855.

Road safety strategies adopted worldwide have made significant progress in reducing road trauma, but have stagnated more recently. The situation in low- and middle-income countries is even worse with no significant decrease in fatality rates. Safety researchers have argued that adopting sociotechnical systems approach is necessary to make significant advancements and improvements. The aim of this study was to develop a

control structure model of the Bangladesh road safety system by identifying the actors and organisations involved across the system. Expert stakeholders were identified and interviewed, and relevant information was gathered in order to generate the Systems Theoretic Accident Model and Process control structure model. Throughout the analysis of this model, differences in the control and feedback mechanisms of the system were identified, and road safety intervention recommendations were made. Future research should also predict potential risks within the system and propose proactive and preventative countermeasures. **Practitioner summary:** In this article, a Systems Theoretic Accident Model and Process control structure model of the Bangladesh road safety system is developed, and the involved actors are identified. Based on interviews and workshops with expert stakeholders, differences in the controls and feedback mechanisms in the system were identified, and road safety intervention recommendations were made.

- **Keywords:** STAMP, sociotechnical system, road safety, control structure, systems thinking

Jamie L. Tait, Timothy P. Chambers, Regan S. Tait & Luana C. Main. *Impact of shift work on sleep and fatigue in Maritime pilots. Pages: 856-868.*

This study examined how objective measures of sleep change across shift-cycles, and the impact of this on sleep quality and fatigue. Forty maritime pilots were recruited from Australian ports. Sleep wake-behaviour (timing and length), and self-reported sleep quality and fatigue, were assessed to determine any impact of roster status and 'on-call' status. On-roster pilots experienced reduced night time sleep duration compared to those off-roster (57 ± 8.8 min), while working on-call also diminished night time sleep duration (126 ± 11.3 min) and quality, compared to workers not on-call. Fatigue scores indicated that participants were not fully recovered prior to commencing rostered night shift, while sleep quality was significantly worse following sleep that occurred after a night shift, compared to after a day shift. These findings potentially support workplace negotiations to change future shift cycles, and to adopt monitoring systems that may mitigate the risk of fatigue-related accidents and chronic health outcomes. **Practitioner summary:** Long and irregular work hours of maritime pilotage can compromise worker performance and safety. This observational study found that on-roster pilots experience reduced sleep duration compared to those off-roster, while working on-call further diminishes sleep duration and quality. Future workload/fatigue monitoring systems may mitigate fatigue-related accidents and adverse chronic health outcomes.

- **Keywords:** Maritime, shift cycle, sleep disruption, on-call actigraphy

Morten Hertzum. *Reference values and subscale patterns for the task load index (TLX): a meta-analytic review. Pages: 869-878.*

The Task Load Index (TLX) is the predominant instrument for self-reporting workload. On the basis of a meta-analytic review of 556 studies, this paper supplies reference values for TLX and its six subscales across domains, technologies, regions, and real-life/lab settings. Across domains, TLX spans mean values from 35 for leisure to 56 for manual labour. TLX tends to be driven upward by the subscales of mental demand and effort and downward by the subscales of physical demand and frustration. For technologies, handheld devices are associated with lower TLX, possibly because they are simpler and more task-specific. TLX also varies across regions in that it is higher for studies in Asia than in Europe and North America. This variation is only partly explained by co-variation in domains. Furthermore, TLX is higher and its subscales more inter-correlated when it is studied in real-life rather than lab settings. **Practitioner summary:** Practitioners can use the reference values supplied in this paper to benchmark their TLX measurements

against those from the corpus of TLX research. Furthermore, the reported subscale patterns add to the diagnostic power of the TLX instrument.

- **Keywords:** Mental workload, NASA-TLX, task load index, TLX, workload

Michael A. Nees & Natalie G. Sampsel. *Simple auditory and visual interruptions of a continuous visual tracking task: modality effects and time course of interference.* Pages: 879-890.

Research has produced conflicting evidence regarding whether performance of an on-going visual task is disrupted more by an interruption from a visual or an auditory alert. Tasks and alerts studied to date have been complex or idiosyncratic. This experiment examined how the modality of simple alerts—visual icons or auditory tones—affected performance of an on-going visual task. Participants (58 females and 4 males) tracked a visual target while performing a choice reaction time task in response to alerts. Visual alerts were more harmful to performance of the tracking task. Dual task workload was lowest with an auditory alert, provided there was not noise present. Interruptions affected tracking task performance for around 1500 ms. Results supported the predictions of Multiple Resources Theory and showed no evidence of auditory preemption. In practical applications for which an on-going visual task is interrupted, auditory alerts may be less disruptive and may reduce perceived workload. **Practitioner Summary:** Many practical scenarios involve on-going visual tasks that are interrupted by simple alerts requiring a simple response. Auditory alerts may be less disruptive than visual alerts and may reduce perceived workload. A conservative estimate is that the effects of even simple interruptions will last a minimum of 1500 ms.

- **Keywords:** multiple resources, auditory preemption, auditory displays, dual task timesharing

Eunjee Kim & Gwanseob Shin. *User discomfort while using a virtual reality headset as a personal viewing system for text-intensive office tasks.* Pages: 891-899.

Ergonomics issues while using virtual reality (VR) headsets for text-intensive applications have not been studied. Measures of neck and shoulder discomfort and simulator sickness symptoms were quantified while participants were performing a document creation task for 60 min using a VR headset and a desktop monitor. During the task with the headset, participants rotated the head 2.7 times more frequently and used the neck extensor muscles 25.9% more, in average. They also rated the neck and shoulder discomfort 60% and 17.5% higher after the task. The simulator sickness symptoms were also rated significantly higher ($p < .05$) for the headset condition, with more pronounced differences in the symptoms related to visual discomfort. Results indicate that the physical discomforts due to the frequent head rotations and the headset weight, and visual discomforts due to difficulty in reading texts were the main issues of the VR headset for common office tasks. **Practitioner summary:** Ergonomics issues associated with the use of a VR headset for conducting office productivity work tasks have been evaluated in an experiment. Study results indicate that the development in the neck physical discomfort and visual discomfort may be the main barriers to the use of current VR headsets for office works.

- **Keywords:** VR HMD, text typing, office ergonomics, virtual office

Weerasak Tapanya, Rungthip Puntumetakul, Manida Swangnetr Neubert & Rose Boucaut. *Influence of neck flexion angle on gravitational moment and neck muscle activity when using a smartphone while standing.* Pages: 900-911.

This study compares the effects of different neck flexion angles on neck gravitational moment and muscle activity of users that stand and operate a smartphone. Thirty-two healthy young adult smartphone users performed texting tasks for three minutes at four different neck flexion angles (0°, 15°, 30°, and 45°) while standing. Neck gravitational moment and cervical erector spinae (CES) and upper trapezius (UT) activity were investigated. When the neck flexion angle increased, the gravitational moment of the neck increased significantly. The muscle activity of CES significantly increased when the neck flexion angle increased, whereas that of UT decreased. The lowest gravitational moment of the neck at 0° flexion was consistent with the lowest CES muscle activity and the lowest neck discomfort score. In conclusion, for texting while standing, adults should maintain their neck posture at 0° flexion to reduce the gravitational force acting on the cervical spine and alleviate neck discomfort. **Practitioner Summary:** During smartphone use when standing, excessive neck flexion (30° and 45° flexion) should be avoided. The suggested neck posture when operating a smartphone while standing is 0° flexion.

- **Keywords:** Neck posture, kinematic, phone tilt angle, gaze angle, discomfort score

Jonathan Terroir, Nellie Perrin, Pascal Wild, Olivier Doutres, Franck Sgard, Chantal Gauvin & Alessia Negrini. *Assessing the comfort of earplugs: development and validation of the French version of the COPROD questionnaire*. Pages: 912-925.

Earplugs are a common form of protection for workers exposed to hazardous noise levels. Their comfort directly impacts the effective protection by influencing their consistent and correct use. Nevertheless, comfort definition may vary according to the studies. Thus, a previous review of the literature has shown that to improve our understanding of perceived comfort and to reduce measurement variability, it is advisable to consider comfort through a multidimensional construct (physical, acoustical, functional and psychological). On this basis, the COPROD (COmfort des PROtections auDitives/COmfort of hearing PROtection Devices) questionnaire was developed. It is intended for people working in noisy environments. Nine earplug models were evaluated by 118 participants over a six-week period. This paper presents the successive analyses that were used to validate the structure of the questionnaire and confirm the relevance of the proposed dimensions and of the addressed items. First results suggest a preference for custom moulded earplugs. **Practitioner Summary:** Earplugs comfort conditions the hearing protection of the users. As the definition of comfort can vary between studies, the COPROD questionnaire was developed to jointly evaluate all its dimensions. Nine earplugs models were evaluated by 118 participants during six weeks. This paper presents the validation process of the questionnaire.

- **Keywords:** Ergonomics tools and methods, earplugs, comfort, questionnaire, sound and noise

Rafaela Bortolini & Núria Forcada. *Regular and temporary occupants' perceptions of satisfaction in tertiary education buildings*. Pages: 926-942.

There is little knowledge about occupants' satisfaction when diverse end users coexist in the same building. This paper presents the results of a survey administered to 1013 occupants in 43 academic buildings in Spain, with the aim to reveal the perception of the indoor environmental quality and workplace ergonomics of both lecturers and students. The results revealed that light adequacy, cleanliness and acoustics in classrooms are perceived differently by lecturers and students. Results also revealed no gender differences in satisfaction with all aspects of comfort in classrooms. However, in offices,

air quality, thermal sensation in winter and adequacy of space were perceived differently by male and female. The findings will be of interest for tertiary building maintenance, design teams and ergonomists to enhance comfort in both groups of end users.

Practitioner Summary: There are no reported studies on how groups of occupants (regular and temporary) perceive comfort in relevant aspects such as acoustics, lighting, space adequacy, cleanliness, and ergonomics. The survey results with 1013 occupants revealed that regular users tend to be less satisfied than temporary users in rooms where they cohabit.

- **Keywords:** End user satisfaction, tertiary education buildings, indoor environment quality, workplace ergonomics, end user characteristics

Mark Kramer & Aaysha Kholvadia. *The effect of vibration cycle ergometry on pulmonary VO₂ kinetics, isokinetic knee torque, and lower extremity explosive power.* Pages: 943-952

Whole-body vibration training is useful for eliciting additional training benefits, but whether vibration-based cycle ergometry would elicit similar benefits has been largely unexplored. Thirteen participants were recruited to investigate differences in vibration (VB) cycle ergometry compared to non-vibration (NV) cycle ergometry with regards to oxygen uptake (V O₂) kinetics, rating of perceived exertion (RPE), heart rate (HR), jumping height, and isokinetic knee joint torque at different intensities and cadences. Meaningful ergometer differences (in favour of VB) were evident for maximal steady state V O₂ HR and RPE, but not for the phase II V O₂ time constant. No meaningful changes were observed for jumping height or isokinetic knee joint torque. The noteworthy increases in V O₂, RPE and HR when using VB ergometry, specifically at higher cadences, and independent of intensity domain, may be linked to changes in muscle fibre recruitment or muscle activation. **Practitioner summary:** Traditional vibration training has purported various beneficial effects, but whether such effects transferred to cycling ergometry was under-researched. Vibration-based cycle ergometry may be a viable method of additionally stressing the cardiovascular system at the same relative intensity compared to non-vibration cycling.

- **Keywords:** Intensity domains, oxygen uptake, post-activation performance enhancement, vibration cycle ergometry